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Structure and composition of the benthic macroinvertebrate community on wetland and irrigated rice cultivation

Estrutura e composição da comunidade de macroinvertebrados bentônicos de área úmida e lavouras de arroz irrigado

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Abstract: Wetlands are environmentally and economically important ecosystems. The irrigated rice crops are considered artificial wetlands, because they offer food and refuge to different aquatic communities. The benthic macroinvertebrates are used to study environmental quality. The knowledge from the organisms which inhabit the natural and artificial wetlands can help to verify less harmful management practices in the agroecosystems. **Aim**: The aim of this research was to analyze and compare the benthic macroinvertebrate community from a wetland and an experimental kind of rice cultivation. **Methods**: It was used dip nets 1 mm mesh every 15 days, with six repetitions in each place, from January to March 2010. After washing and screening them in the laboratory, the organisms were identified using stereoscope microscope and identification keys, and classified according to their functional trophic group. **Results:** The whole organisms collected were 33,293 specimens. It was found 34 taxa, being 26 founded in the rice crops and 31 on the wetland. The natural wetland shows greater abundance, being responsible for 90.47% from the total abundance in this study. In the rice crop the abundance and the richness increased in the course of collection. However, it did not reach the values founded in the wetlands during the cultivation period. The most found groups in the two environmental were Belostomatidae and Planorbidae, while Hyalellidae and Elmidae were found only in the wetland, being a stress indicator in the wetland. **Conclusions**: The community structure including abundance, richness and composition was statistical different between wetlands and rice cultivation.

Keywords: natural wetlands, benthic macroinvertebrate, trophic functional groups, artificial wetland, impact.

Resumo: Áreas úmidas são ecossistemas de importância ambiental e econômica. As lavouras de arroz irrigado são consideradas áreas úmidas artificiais, pois fornecem alimento e abrigo para diferentes comunidades aquáticas. Os macroinvertebrados bentônicos vêm sendo amplamente utilizados como ferramenta para estudos de qualidade ambiental. O conhecimento dos organismos que habitam as áreas úmidas naturais e artificiais pode auxiliar na verificação de práticas de manejo menos impactantes nesses agrossistemas. **Objetivo:** O objetivo desta pesquisa foi analisar e comparar a comunidade de macroinvertebrados bentônicos de uma área de úmida natural (banhado) e uma lavoura experimental de arroz irrigado. **Métodos:** Foram realizadas coletas com rede de mão com malha de 1 mm a cada 15 dias, com seis repetições em cada local, durante o período janeiro de 2010 a março de 2010. **Resultados:** Foi coletado um total de 33.293 indivíduos. Quanto à riqueza, foram encontrados um total de 34 táxons, sendo 26 destes encontrados na lavoura e 31 no banhado. O banhado apresentou maior abundância, totalizando 90,47% dela. Na lavoura, tanto a abundância quanto a riqueza aumentaram sucessivamente no decorrer das coletas, porém não atingindo os valores encontrados no banhado, durante o período de cultivo. Os grupos mais encontrados nos dois ambientes foram organismos da família Belostomatidae e Planorbidae. Hyalellidae e Elmidae apareceram somente no banhado, podendo ser um indicador do grau de impacto nesses agroecossistemas. **Conclusões:** Através das análises estatísticas pôde ser observada uma diferença significativa na estrutura da comunidade, incluindo abundância, riqueza e composição, nas amostras do banhado e da lavoura.

Palavras-chave: áreas úmidas naturais, macroinvertebrados bentônicos, grupos funcionais tróficos, áreas úmidas artificiais, impactos.

1. Introduction

Wetlands are important ecosystems, highly productive and with high biological diversity, being considered of high priority conservation. These ecosystems are suffering anthropic modifications being converted to agriculture and livestock, for example. The knowledge about ecological process that are modified by the activities developed in these sites can subsidy decision making about the uses and management that offer preservation to this process.

In the wetlands, the irrigated rice cultivation causes modifications, listed by Chomenko (1997), such as reduction of natural ecosystems; variation of groundwater; compaction, reduced porosity and soil salinization, water supply shortage. These impacts, together with the use of agrotoxic could change the water quality and sometimes could exceed the ecosystem resilience. Given that, it would be impossible to sustain the biota that lives in wetland and adjacent habitat.

Despite harmful, this is a very important crop, being the Rio Grande do Sul state one of the most important rice producer at Brazil, with 1,050,000 ha with this cultivation, producing about 6,000 $kg.ha^{-1}$, corresponding to 50% of Brazilian rice producing (IRGA, 2006). The southern zone of Rio Grande do Sul is responsible for 16.6% of rice crop area from the state, which means 171,555 ha (IRGA, 2006). These regions municipalities show big plains with a greater part of these soils with limited drainage and flood plains as in the municipality of Capão do Leão (27.91%) and Rio Grande (69.0%) (Winckler-Sosinski, 2009), which makes it easy the flood irrigation used to these crops. Although the anthropic alterations, the rice crops are environmental that have ecological functions because they are used to host a lot of organisms, both shelter and food as for reproduction. These crops are considered, according to Ramsar Convention (2006), artificial wetlands.

Studies focusing on the biota that are found in these areas are fundamental to create alternative management practices to mitigate the impact in these ecosystem's biological structure and function.

Benthic macroinvertebrates are easy to collect and have relative easy identification, having diversified responses to different levels of disturbance, reflecting the state of the whole aquatic ecosystem (Reice and Wohlenberg, 1993). Furthermore, the trophic guilds provide relevant information about the ecosystem function and may be affected by habitat availability and other changes in the ecosystems (Callisto et al., 2001). The characterization of the wetland and rice cultivation communities allows us to understand the changes imposed by human disturbance, and provides knowledge about the crop management dispensed, subsidy information which provides sustainable use in artificial wetlands.

The aim of this study was to characterize and compare taxonomically and functionally the benthic macroinvertebrate community presented in artificial and natural wetlands in the extreme south of Brazil.

2. Material and Methods

The samples were collected in a wetland from the São Gonçalo Channel system and in experimental rice plots cultivation (31°52'00" S, 52°21'24" W), both of them located at Estação Experimental Terras Baixas (EETB) from Embrapa Temperate Climate, at the Capão do Leão municipality, at Rio Grande do Sul state. The experimental plots were 180 m^2, with the convectional management according SOSBAI (2007), and approximately 15 cm of flood water. It was sown with Fronteira seed at November 13, 2009. The fertilizer application was 300 kg/ha from NPK (01-25-25).

The wetland is approximately 1500 ha (Pinheiro and Dias, 1998). The samples were collected in the delimited area by nets at the same area as the rice cultivation (180 m^2), at sites with approximately the same water depth (15 cm), this being measured by a ruler.

All samplings occurred from January to March 2010, coinciding with the period of rice cultivation, totalizing six samplings in each environment. The samplings were conducted on January (01/14, 01/27), February (02/11, 02/26) and March (03/15 and 03/31). The sampling effort was with four people with dip nets with 1 mm mesh traversing the crop and the wetland for 20 minutes. The sampled organisms were sent to the ecotoxicology and biomonitoring laboratory at EETB, where screening was done and the specimens was preserved at alcohol 70%. After this, the organisms were identified until the last taxonomic level that was possible and grouped according the trophic functional groups (TFG) according Stenert (2009), Copatti (2010) and Costa (2006).

During the sampling pH, conductivity and temperature was verified with digital pHmeter Digimed model DM2P, digital conductivimeter Digimed DM3P and mercury thermometer, respectively.

The randomization test using Euclidean distance was done using software MULTIV v2.4.2 (Pillar and Orlóci, 1996) to verify composition, richness, abundance and TFG differences between rice cultivation and wetland.

3. Results

The abiotic information of water was presented in Table 1. The conductivity was always higher in the wetland than in the rice cultivation.

There were found 33,293 organisms, being the wetland responsible for 90.47% of the abundance of total collected organisms. It is possible to observe statistical differences in richness (p=0.029), abundance (p=0.028) and benthic macroinvertebrate composition (p=0.03) between wetland and rice cultivation.

The most abundant organisms were Belostomatidae (7.265 specimens), followed by Planorbidae (6.427 specimens), which occurred mainly at wetland. Physidae was the only group that occurred exclusively in the rice cultivation.

34 taxa were found, 26 at the rice cultivation and 31 at the wetland (Table 2). Hyalellidae and Elmidae were presented only at the wetland.

It was observed a successively increased in abundance and richness during the sampling period (Figure 1), mainly in rice cultivation.

The organisms were divided at six trophic functional groups according to their food category: predator, generalist, shredder, collector, scraper and parasite (Figure 2). The randomization test presented significant differences (p=0.033) at TFG when compared wetland to rice cultivation. Among the benthic macroinvertebrate found at the rice cultivation, the shredders and scrapers have participated much less than in wetland.

4. Discussion

Wetlands are rich in humic compounds and low levels of pH and can present high values of electric conductivity, according to Esteves (1998). Santos (2008) states that the wetland conductivity positively influences some animal communities.

The increasing abundance along the sampling period in wetland and rice cultivation can be explained by the system hidroperiod. In March, the abundance of wetlands has a slightly decrease compared to the previous month, while in rice cultivation it still increases. This increase could be explained by the colonization that is occurring at this environmental once the rice crops are flood since December. However, this abundance did not reach the wetlands values during the cultivation period that reach only four or five months).

The Hyalellidae and Elmidae family were presented only at the wetland probably due to the degree of interference at rice crops and it may being an indicator of the degree of impact at these agroecosystems, while the Physidae family can establish population at this kind of artificial environment.

Compared to the study presented by Perera (2010), using near sample areas, it is possible to notice similarities in the richness values founded in this study to different environment. However, there are different community composition, being observed representatives of other groups such as Ostracoda, Acari, Trichoptera e Plecoptera that not occurred in this study, except the first one

Table 1. Abiotic water parameter analyzed during the collection period.

Month	Wetland			Rice Cultivation		
	pH	Conductivity (μs.cm^{-1})	Temperature (°C)	pH	Conductivity (μs.cm^{-1})	Temperature (°C)
January	5.55	184.15	26.55	5.95	77.15	27.30
Standard Deviation	0.21	23.83	2.19	0.07	11.38	0.42
February	6.15	153.50	30.20	6.70	45.30	27.95
Standard Deviation	0.07	89.80	4.53	0.00	5.23	5.02
March	6.45	119.25	27.60	8.00	86.60	27.60
Standard Deviation	1.34	11.38	1.13	0.99	17.82	4.95

Table 2. Abundance of collected organisms at wetland (Wet) and rice cultivation (Ric).

Taxa*	Collect 1		Collect 2		Collect 3		Collect 4		Collect 5		Collect 6		Total
	Ric	Wet	Ric	Wet	Ric	Wet	Ric	Wet	Ric	Wet	Ric	Wet	
Gastropoda	-	-	-	-	-	-	-	-	-	-	-	-	-
Ampularidae (Sc)	-	4	-	2	-	3	-	-	15	6	51	7	88
Planorbidae (Sc)	-	1251	8	393	-	427	1	2034	-	1481	4	828	6427
Physidae (Sc)	11	-	12	-	7	-	181	-	104	-	208	-	523
Hirudinida (Pa)	-	-	-	18	-	-	-	11	1	1	2	-	33
Oligochaeta (C)	1	-	1	-	-	-	-	-	-	-	-	-	2
Ostracoda (G)	-	1	2	-	-	-	-	-	-	-	-	-	3
Amphipoda	-	-	-	-	-	-	-	-	-	-	-	-	-
Hyalellidae (C)	-	62	-	76	-	3	-	27	-	7	-	13	188
Ephemeroptera	-	-	-	-	-	-	-	-	-	-	-	-	-
Baetidae (Sc)	-	618	-	682	-	60	-	24	7	61	27	7	1486
Caenidae (C)	-	140	-	17	-	8	47	304	20	508	128	416	1588
Odonata	-	-	-	-	-	-	-	-	-	-	-	-	-
Aeshnidae (Pr)	-	-	-	6	-	1	-	-	-	2	1	-	10
Libellulidae (Pr)	16	87	4	107	30	197	131	139	73	251	255	969	2259
Protoneuridae (Pr)	-	22	7	130	16	232	55	381	64	168	92	57	1224
Hemiptera	-	-	-	-	-	-	-	-	-	-	-	-	-
Belostomatidae (Pr)	44	220	21	727	19	1470	37	1519	45	2178	55	930	7265
Corixidae (G)	-	172	5	17	5	1	10	10	45	30	31	8	334
Mesoveliidae (Pr)	1	-	-	-	-	-	-	-	-	-	-	1	2
Nepidae (Pr)	-	-	-	-	-	-	-	1	-	-	-	-	1
Notonectidae (Pr)	3	192	4	64	27	2	21	23	12	16	13	27	404
Coleoptera	-	-	-	-	-	-	-	-	-	-	-	-	-
Curculionidae (Sh)	-	-	-	-	-	-	3	75	-	-	-	1	79
Dryopidae (G)	-	4	-	-	-	-	-	-	-	-	-	1	5
Dysticidae (Pr)	2	-	1	1	6	1	3	6	1	-	4	15	40
Elmidae (C)	-	9	-	1	-	10	-	1	-	2	-	-	23
Gyrinidae (Pr)	-	2	1	2	-	-	-	-	-	-	-	-	5
Haliplidae (Pr)	-	-	-	-	-	13	1	18	-	5	-	4	41
Hydrochidae (Sh)	-	3	-	-	-	-	-	-	-	-	-	-	3
Hydrophilidae (G)	2	97	4	200	3	88	3	47	3	53	8	30	538
Noteridae (G)	-	-	-	-	-	4	-	26	-	24	-	30	84
Diptera	-	-	-	-	-	-	-	-	-	-	-	-	-
Chironomidae (G)	-	122	31	51	60	22	77	686	295	136	617	2003	4100
Chaboridae (Pr)	-	1	-	-	-	-	-	1	-	8	-	30	40
Psychodidae (C)	-	7	-	27	-	60	1	14	-	-	-	-	109
Lepidoptera	-	-	-	-	-	-	-	-	-	-	-	-	-
Pyralidae (Sh)	7	139	11	513	11	3065	-	1288	-	-	-	333	5367
Allochthonous	8	4	6	147	3	199	3	361	8	136	9	138	1022
Total	95	3157	118	3181	187	5866	574	6996	693	5073	1505	5848	33293

*The letters behind the taxa represent the trophic functional group, being: C: collector; Sh: Shredder; G: Generalist, Pr: predator; Sc: scraper; Pa: parasite.

that appears as a rare group. These differences in community composition can be related to the collect methods. While Perera (2010) used core to collect sediments up to 5 cm deep while in this particular study dip nets were used, being possible to collect bigger organisms that are free at water column such as Belostomatidae, which did not appear at Perera (2010).

The predator and generalist predominance at rice crops are associated to food availability in this environment, once the tillage allowed a recent colonization and food availability. However, after some months with flood irrigation it is possible to realize increases that were already present and new one star appear, such as generalists that appear in greater quantity. These observations are similar for Stenert (2009), when predators and generalists are the dominant trophic group at rice cultivation, along with collectors.

Among the benthic macroinvertebrate found at the rice cultivation, the shredders and scrapers have less participation than in wetlands, probably due

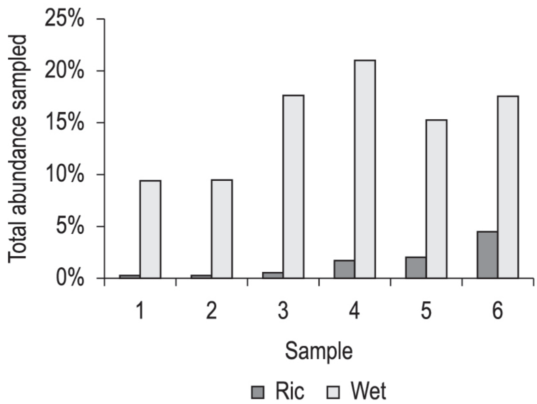

Figure 1. Relative abundance observed at the wetland and rice cultivation relative to total abundance sampled at the study environments.

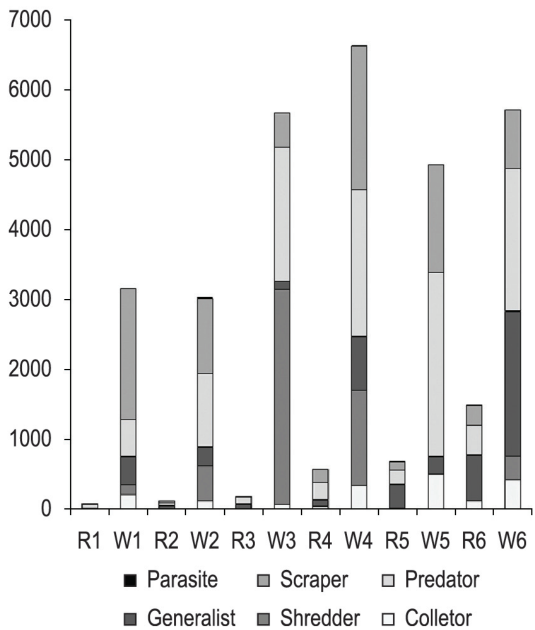

Figure 2. Abundance of trophic functional groups founded at rice cultivarion (R) and wetlands (W) at different sample periods (1 and 2 – January, 3 and 4 – February, 5 and 6 – March).

to organic matter that is not so available at the rice cultivation. Functional groups are aggregated during the irrigation period in rice cultivation, suggesting that the similarities with wetlands can be higher if the water retained inside the rice cultivation area outside the period of cultivation, according purposed by Stenert (2009).

The wetland has more diversity and abundance of benthic macroinvertebrate than rice cultivation, even though the rice cultivation have benthic macroinvertebrates that could help to sustain aquatic communities such as aquatic birds or fish, which feed on site, in the drainage canals or water bodies underlying. It is necessary to study different management practices that can help define the agricultural practices more favorable for the maintenance of functionality of these artificial wetlands.

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